PLANT SAFETY REVIEW FROM MASS CRITICALITY ACCIDENT

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ABSTRACT

PLANT SAFETY REVIEW FROM MASS CRITICALITY ACCIDENT. The review has been done to understand the resent status of the plant in facing postulated mass criticality accident. From the design concept of the plant all the components in the system including functional groups have been designed based on favorable mass/geometry safety principle. The criticality safety for each component is guaranteed because all the dimensions relevant to criticality of the components are smaller than dimensions of "favorable mass/geometry". The procedures covering all aspects affecting quality including the safety related are developed and adhered to at all times. Staff are indoctrinated periodically in short training session to warn the important of the safety in process of production. The plant is fully equipped with 6 (six) criticality detectors in strategic places to alert employees whenever the postulated mass criticality accident occur. In the event of Nuclear Emergency Preparatness, PT BATAN TEKNOLOGI has also proposed the organization structure how promptly to report the crisis to Nuclear Energy Control Board (BAPETEN) Indonesia.

INTRODUCTION.

The plant to produce nuclear fuel element for research reactors has been operated since 1987 to supply fuels for RSG-GAS. In May 24, 1996, the asset of the plant has been transferred to state owned company (PT Batan Teknologi). During ten years production the plant has shown a good performance to produce fuel element in high quality standard and conforms to the international standard used by other manufacturer in the world. The plant is designed to handle enriched uranium up to 20% enrichment, and able to produce the plate type and control elements for research reactors. It consists of conversion, fabrication and scrap recovery plant, as well as analytical laboratory for QC of incoming material, intermediate and final products.

In the design of equipment, the type of criticality control to be used must be considered. Once the control method is established, the process and equipment must be designed to meet the limiting values of the control method used. Basically, the plants may be designed using mass, concentration, volume, geometry control and combination thereof.

The design concept of this plant is based upon the criticality assessment where the existing of uranium enriched up to 20% is considered in all construction phases. All the equipment's to handle uranium either in the conversion and fabrication plant was constructed based on favorable geometry safety principle and mass criticality calculation assessment.

The factors affecting the critical mass of fissionable materials are: (1) mass of material, (2) enrichment (or isotopic purity), (3) volume of the material, (4) shape, (5) size, (6) concentration of fissionable material in solutions, (7) moderation, (8) reflection, (9) interaction, and (10) poisons. The first five factors are very important for control purposes in designing equipment's where the uranium enriched are handled. For design purposes however, the moderation and reflection are usually assumed as optimum for criticality.

Lesson learn from Tokaimura critical mass accident last September 30, 1999 the management in Nuclear Fuel Element Production Division of PT Batan Teknologi have instructed to all staff and engineer to review all the documents related to safety and the implementation of quality assurance program in daily activities. In October 1999, a short training program /Indoctrination training related to criticality accident has been done to alert the staff the importance of the safety in all their works.

1.Review of The Design Concept

Review of the safety concept to all part of our plant is very important to understand the resent status of the equipment and to inform all employees that all equipment's are safe for operation. The review would be for AUC conversion, Calcination and Reduction, Hydro-fluorination, Calciothermic reduction, dissolution, filtration, annealing, extraction, evaporation, liquid radioactive waste collection system and functional groups. The results from " SOLRF – A Program " for the approximate calculation of the neutron interaction according to the solid angle methods, and report from W. Bauerle at al about Criticality Parameters for The Fissile Material Systems Present in the MTR Fuel Element Plant/Batan Indonesia have been used for the purpose of the review.

1.1 AUC CONVERSION.

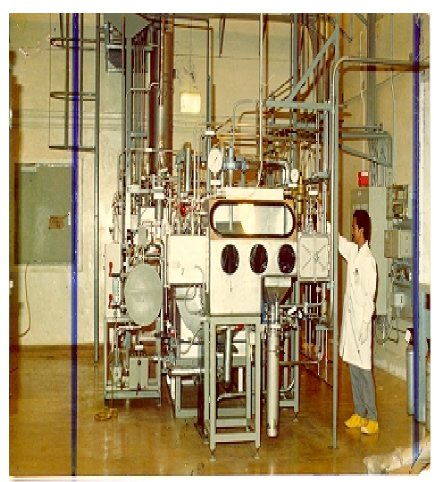
In this system, UF6 or uranyl nitrate solution is converted to Ammonium uranyl carbonate (AUC). The following fissile materials are: UF6, UF4, AUC, ADU, UO2F2 and uranyl nitrate. The individual component has been designed conservatively. The safety principle in this system is" favorable geometry" in which the dimensions of the individual components for the slab thickness is 7,2 cm and for cylinder diameter is 17.1 cm. From the review we have found that all dimension of components in this system are smaller than the dimension given above. The scrubber used in this system is not designed in favorable geometry, but the criticality safety is guaranteed by central rod made of the neutron poison B_4C (boron carbide).

UF6 EVAPORATION UNIT

The heating of UF6 bottle in the UF6 evaporation tank take place with the aid of hydrogen free fluorocarbon, so that the present fissile material here is unmoderated.

1.2 CALCINATION AND REDUCTION

In this system, AUC is converted to U_3O_8 or to UO_2 . The fissile materials in this system are AUC, U_3O_8 and UO_2 powder. The most reactive fissile material system used as the basis here is UO_2. The safety principle is favorable geometry, where the dimensions of the individual components for the slab thickness is 6.8 cm and for cylinder diameter is 16.0 cm. From the review we have found that all dimension of components are smaller than the dimension given above. The Sieving Box is not designed in favorable geometry, but the criticality safety is guaranteed because the amount of the fissile material is smaller than the favorable mass for unmoderated fissile material.



CALCINATION AND REDUCTION UNIT

1.3 HYDROFLUORINATION

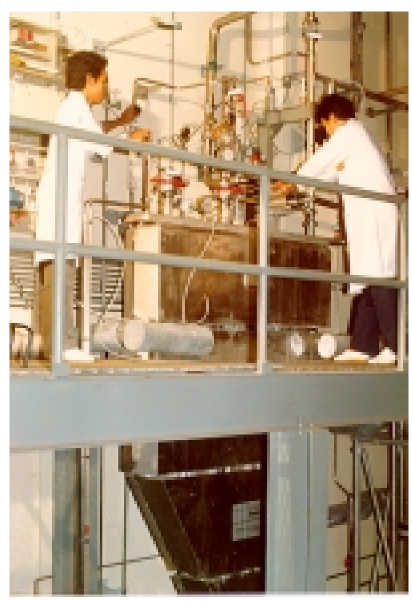
In this system, UO_2 is converted to UF_4. The most reactive fissile material system used for the criticality assessment is UO_2. The criticality design of the component is carried out according to the principle of "favorable geometry" in which for the slab thickness is 6.8 cm and for cylinder diameter is 16.0 cm. From the review we have found that the dimensions relevant to the criticality of the components are smaller than the dimension given above, the criticality safety in this system is guaranteed.

1.4 CALCIOTHERMIC REDUCTION.

In this system the UF_4 is converted /reduced to uranium metal. From the review we have found that the fissile material is present unmoderated, in the scale, mixer and container for reduction. The uranium mass per batch (about 5 kg of uranium) present at the individual working positions is smaller than the favorable mass to be used in this system (12,65 kg U) so that the criticality safety is guaranteed.

1.5 DISSOLUTION, FILTRAION, ANNEALING

In this system, the material streams UAlx , U_3O_8-Al and U_3Si_2 –Al scrap, CaF_2 slag, and other solid waste materials containing uranium are reprocessed through the processing steps : dissolution, filtration and annealing. The following materials may be present: UAlx, U_3O_8, U_3Si_2., UO_2, and uranyl nitrate. From the review we have found that the most reactive fissile material system used (except for the dissolver) as the basis is UO_2. The safety principle in this system is "favorable geometry" for the slab thickness is 6.8 cm (5.4 cm for the dissolver) and cylinder diameter is 17.1 cm. The criticality safety is guaranteed because all the dimensions relevant to criticality of the components are smaller than dimensions given above.



DISSOLVER UNIT

1.6 EXTRACTION

In this system, the uranyl nitrate solution with various concentration (40 – 200 g U/l) is purified through extraction and re-extraction and is set to a concentration of 80 g U/l. No other fissile material systems are present. From the review we concluded that the criticality safety is guaranteed because all the dimension of the components are smaller than favorable geometry (8.5 cm for slab thickness and 17.1 cm for cylinder diameter).

1.7 EVAPORATION

In the evaporation system uranyl nitrate solution with uranium content around 80 g U/l is concentrated up to 400 gU/l through evaporation. From the review we have found that the uranyl nitrate solution is used as the basis for the criticality design. The criticality safety is guaranteed because all the dimension of components are smaller than “ favorable geometry” used in this system (slab thickness is 8.2 cm and cylinder diameter 18.9 cm).

1.8 LIQUID RADIOACTIVE WASTE COLLECTION

In this system the liquid radioactive wastes from AUC conversion, Hydro - fluorination, Dissolution and extraction are collected in the Tanks. From review, has been found that contents of uranium in liquid waste shall be less than 50 mg uranium/l. Because the volume of each tank is 1 m^3, the maximum mass of uranium per tank is only 50 g. This quantity is far below the critical mass, so that the criticality safety of this system is guaranteed.

1.9 FUNCTIONAL GROUPS

The functional group includes the following system: UAlx/U3Si2 production, UAlx or U3Si2 picture production, Fuel plate production, structure part manufacturing and fuel element assembly. For the purpose of guaranteeing the criticality safety the functional groups can be divided into two groups i.e.:

1. All working positions at which a moderator is present in the form of water (cooling, solvents, paper, wood, polyethylene are conservatively designed according to optimum moderation. The maximum favorable mass to be handled at these working positions is 2.23 kg of uranium, the degree of moderation ratio H/U = 86.
2. All working positions at which fissile material is processed unmoderated (dry, without packing material) are conservatively designed according to moderation ratio H/U = 10. The maximum favorable mass to be handled at these working positions is 12.65 kg of Uranium.

2. REVIEW OF THE EXISTING QUALITY ASSURANCE PROGRAM.

Company recognizes the important of the existing of quality assurance program as a tool to guide the staff in the production daily activities. The procedures covering all aspects affecting quality including the safety related are developed and adhered to at all times. The procedures used in the program including work instruction are implemented and continually under review and improvement. Education and training to understand company policy, are achieved through induction and structured training program. Periodically staffs are indoctrinated in short training session to warn the important of safety in process works. At least there were 17 procedures related to the safety including a procedures to handle a postulated mass critical accident are reviewed and up-dated. Special training session is held regularly to alert all staff the importance of the following:

1. to follow the instruction written in the criticality card control in all devices/equipment's.
2. Avoiding the flood, spraying other material in water groups, oil, wood etc.
3. Avoiding the additional of reflector materials such as (graphite, beryllium etc.)
4. Avoiding the placement/the use of unit of equipment in the wrong place.
5. to check periodically the loss of neutron absorber (if any)
6. To remember the favorable critical mass for each process of equipment.
7. To remember the change of fissile material density during process production.
8. Not to change the unit of equipment that cause unsafe geometrically.

In addition, the plant is fully equipped with 6 (six) criticality detector in strategic places to give an early warning to employees whenever the postulated mass criticality accident occur. The signal alarm will active when the radiation exposure exit the limit 10 mR/hour over background.

3. ACTION TO BE TAKEN IN THE EVENT OF POSTULATED MASS CRITICALITY ACCIDENT.

The Division has prepared a procedure and training session to anticipate the postulated mass criticality accident. The actions to be taken during the crisis are:

1. The management will promptly report to BAPETEN (National Energy Control Board) and in coordination with the Center for Management and Industrial Establishment to take an action during and after the crisis.
2. The personnel/worker leave the building soon, and go the BATAN BUNKER near clinic located at Serpong site.
3. The protection and radiation staff monitors and measure the radiation dose released and to check the total workers.

In the event of Nuclear Emergency Preparatness the Company has also proposed the Organizational structure how promptly to report the crisis to Nuclear Energy Control Board (BAPETEN) Indonesia. The proposed Organization Chart – Nuclear Emergency Preparatness as shown in the attachment.

4. CONCLUSION

From review that has been mention above we can conclude the following:

1. From the design concept of the plant, all the equipment's in the AUC conversion, calcination and Reduction, hydrofuorination, calciothermic reduction, dissolution, filtration, annealing, extraction, evaporation, liquid radioactive waste and functional groups have been designed based on favorable mass/geometry safety principle. The

criticality safety for each component is guaranteed because all the dimensions relevant to criticality of the components are smaller than dimensions of “favorable geometry”.

2. The scrubber and Sieving/Glove box are not designed in favorable geometry, but the criticality safety are guaranteed, because the existing neutron poison and maintained the amount of the fissile material far below favorable mass.
3. The procedures covering all aspects affecting quality including the safety related are developed and adhered to at all times. Periodically staff are indoctrinated in short training session to warn the important of the safety in process of production.
4. The plant is fully equipped with 6 (six) criticality detectors in strategic places to alert employees whenever the postulated mass criticality accident occur.
5. In the event of Nuclear Emergency Preparatness, Company has also proposed the organization structure how promptly to report the crisis to Nuclear Energy Control Board (BAPETEN) Indonesia.

REFERENCES.

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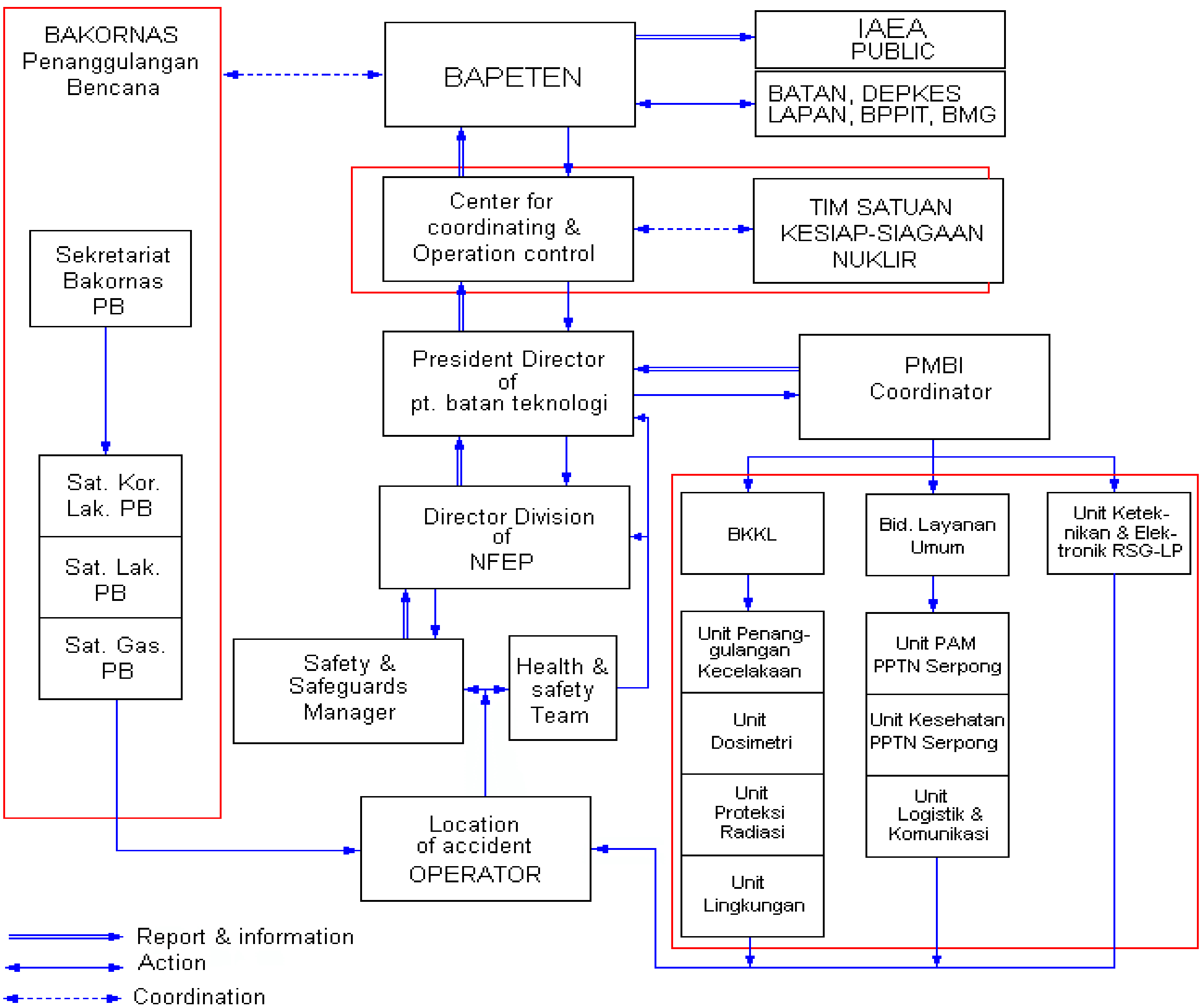
4. W. Thomas, SOLRF – A Program for the Approximate Calculation of the Neutron Interaction according to the Solid Angle Method, NUKEM Internal Working Report T-34, Hanau, October 1971.

ATTACHMENT
PROPOSED ORGANIZATION STRUCTURE FOR NUCLEAR EMERGENCY PREPARATNESS



ORGANITATION CHART - NUCLEAR EMERGENCY